JOB HAZARD ANALYSIS

Location(s):	Wang NMR 550 N. Canyons Pkwy. Livermore, CA 94551	Analysis By:	Steve Virostek	Date: Expires:	1/18/13 8/31/13
Division:	AFRD	Work Leader:	Steve Virostek	Frequency:	One-time
Category:	Task-based			JHA Number:	N/A
Job Title:	MICE Spectrometer Solenoid Testing at Wang NMR in Livermore, CA				

REQUIRED PERSONAL PROTECTIVE EQUIPMENT:

- Latex gloves and safety glasses w/side shields are required for handling cleaning chemicals.
- Cryogenic rated gloves and safety glasses w/side shields are required for handling cryogens and related equipment.
- A face shield is also required when working with the transfer of cryogens from a pressurized dewar

SCOPE DESCRIPTION: The scope of work is participation in the assembly and testing of the MICE Spectrometer Solenoid superconducting magnets at the private company Wang NMR in Livermore, CA. Assembly work primarily consists of surface cleaning, installation of instrumentation, and application of multi-layer insulation (MLI). Specific details are provided for each of the tasks on subsequent pages and in attached documents.

Task #	Description	Hazard(s)	Control(s)
1	Surface cleaning for magnet assembly	Use and storage of cleaning chemicals such as isopropyl alcohol and acetone	A lockable storage cabinet rated to contain these chemicals has been procured for use at Wang NMR. Latex gloves and safety glasses w/side shields are required PPE.
2	Insertion of stinger into magnet fill line	Installation of the stinger requires working at heights and handling cryogenic equipment	A stairway system with railings has been incorporated for fall protection. Cryogenic rated gloves and safety glasses w/side shields are required PPE. Closed toe shoes, long pants and a long sleeved shirt are also required.
3	Magnet cooldown prior to testing and magnet quench during testing	Working with cryogens is required. The possibility of ODH is present. Other hazards include a large vacuum vessel and a pressurized helium vessel.	Cryogenic rated gloves, safety glasses w/side shields, closed toe shoes, long pants and a long sleeved shirt are required PPE for handling cryogenics. The ODH hazard class was determined to be 0. A safety note for the helium vessel and vacuum vessel has been generated.
4	Operation of magnet power supplies	An electrical hazard is present, primarily in the 208V electrical power to the magnet power supply rack.	The power supply racks have been upgraded at LBNL to the appropriate safety standards, including physical barriers to prevent access to energized circuits. Magnet lead voltages during operation and quench are <20 volts.
5	Testing of magnets with current in superconducting coils	A relatively high level of magnetic field is present in the area of the magnet. A potential ODH hazard is present during magnet quench.	The peak magnetic field map has been determined, and the 5 gauss line will be marked with caution tape. Pre-test searches for magnetic tools and parts will be conducted. The ODH hazard class was determined to be 0.

AUTHORIZED WORKER(s) INFORMATION:

WORKER ID NUMBER:	WORKER NAME	AUTHORIZED TASKS		
812724	Steve Gourlay	N/A		SUPERVISOR AUTHORIZATION[2]
250003	Steve Virostek	2, 3, 4, 5		SUPERVISOR AUTHORIZATION[2]
129735	Dennis Calais	1, 2, 3, 4, 5		WORKER SIGNATURE[1]
028553	Roy Preece	1, 2, 3, 4, 5		WORKER SIGNATURE[1]
224151	Allan DeMello	3, 4, 5		WORKER SIGNATURE[1]
028310	Heng Pan	2, 3, 4, 5		WORKER SIGNATURE[1]
030204	Tianhuan Luo	3, 4, 5		WORKER SIGNATURE[1]
030629	Andrew Lambert	3, 4, 5		WORKER SIGNATURE[1]
682501	Nanyang Li	3, 4, 5		WORKER SIGNATURE[1]
004974	Soren Prestemon	2, 3, 4, 5		WORKER SIGNATURE[1]
024140	Kyle Mccombs	1, 2, 3, 4, 5		WORKER SIGNATURE[1]
018807	Adrian Williams	1, 2, 3, 4, 5		WORKER SIGNATURE[1]

[1] *Worker signature indicates concurrence with the analysis and agreement to work in accordance with this authorization.*
[2] *Supervisor signature above authorizes the work subject to the controls specified.*

TASK DETAILS:

Task 1: Surface cleaning for magnet assembly

Several of the tasks carried out by LBNL personnel involve the use of cleaning chemicals (specifically, isopropyl alcohol and acetone). A lockable storage cabinet rated to contain these chemicals has been procured by LBNL and transported to Wang NMR in Livermore. All chemicals are stored in the cabinet while not in use. Container sizes include 1 and 2 gallon bulk supply containers and 1 liter polyethylene squirt bottles. At the conclusion of the LBNL tasks at Wang NMR, all chemicals will be left with the vendor and will not be transported back to LBNL. When using the chemicals for cleaning surfaces and parts, LBNL personnel will use latex gloves and safety glasses w/side shields.

Task 2: Insertion of stinger into magnet fill line

LBNL personnel will participate in one task at Wang NMR involving working at heights. The task will be to insert the cryogenic stinger on the transfer line into the magnet fill port on one end and into the LHe dewar on the other end. The magnet fill port is approximately 8 feet above floor level, and the dewar liquid valve is approximately 6 feet above floor level. To accomplish this task, LBNL has procured and transported to Wang NMR a pair of steel rolling stairways with hand rails. One of the stairways is shown in Figure 1 next to the Spectrometer Solenoid magnet. In order to access the fill port on the magnet, the two rolling ladders will be placed on opposite sides of the magnet, facing the fill port tower. In order to allow convenient access to the fill port area, a platform extension will be installed on either side from the stairway to the magnet along with the appropriate hand railings. Cryogenic rated gloves, safety glasses w/side shields, and a face shield are required during all of the stinging operations.

It is anticipated that this operation will only be carried out twice during magnet testing: once for the LN cooldown line that is initially inserted into the magnet fill port, and once for the LHe transfer line that is inserted at the completion the LN cooldown. The stinging of the LHe dewar will be carried out 6 to 8 times during magnet testing to allow for replacement of the dewars as they are used. One of the rolling ladders will be placed next to the dewar to allow the user to climb part way up the stairs and insert the stinger. A face shield will also be required when transferring cryogens from a pressurized dewar or vessel.

All other tasks requiring working at heights (installation of cryocoolers, welding of the vacuum vessel, etc.) will be carried out by Wang NMR personnel and their subcontractors.

Task 3: Magnet cooldown prior to testing and magnet quench during testing

This task involves the following potential hazards: working with cryogens (LN and LHe), the possibility of oxygen deficiency hazard (ODH), a large vacuum vessel and a pressurized helium vessel. All of the potential hazards have been addressed separately.

Working with cryogens will necessitate that all workers are properly trained and have the appropriate personal protection equipment (PPE). The following LBNL training course addresses the safe handling of liquid cryogens: EHS0170 Cryogen Safety. All participating LBNL employees will have completed this course. During any operations involving cryogenics, appropriate gloves and safety glasses w/side shields are required; A face shield will also be required when transferring cryogens from a pressurized dewar or vessel.

The possibility of ODH has been assessed for the entire test setup at Wang NMR. In Chapter 29: Safe Handling of Cryogenic Liquids in LBNL's PUB-3000, guidelines are provided for assessing a system's potential for ODH. In Section 29.4 titled 'Required Work Processes', Work Process C: Oxygen-Deficiency Risk Assessment provides a numerical tool for assessing the potential hazard level for ODH in spreadsheet format. The analysis was conducted for the Wang NMR test facility dimensions and the various volumes and types of cryogen storage on site. The output sheet from the calculator is shown in Figure 2 for reference. The hazard class for the Spectrometer Solenoid testing was found to be Level 0, corresponding to a probability risk of $<10^{-7}$ fatalities per hour. For this classification, no further controls are required.

The Spectrometer Solenoid vacuum vessel contains a cold mass with approximately 190 liters of liquid helium inside during operation. The cold mass is essentially an aluminum bobbin wound with 5 superconducting coils and with a welded aluminum cover plate. During filling and normal operation, the cold mass internal pressure is limited to 8 psig by a large bore relief valve. During a magnet quench, the cold mass internal pressure can reach up to 20 psig. For the worst case calculation with vacuum on the outside of the cold mass, the stored energy for the 200 liter volume at 20 psig was calculated to be 72.4 kJ. According to Section 7.5.1 of PUB-3000, air and inert gas systems at a pressure <150 psig and with a total stored energy of <100 kJ are considered to be low-hazard pressure systems. For this type of system, there are no special controls other than that those people working on these systems must have completed EHS0171: Pressure Safety (previously EHS0231).

The stored energy of a vacuum vessel is equal to atmospheric pressure multiplied by the volume of the vacuum space. This calculation results in approximately 100 kJ of stored energy per cubic meter of volume. The Spectrometer Solenoid vacuum vessel has a volume of 4.48 m^3, resulting in 448 kJ of stored energy. However, the vacuum vessel does not generally pose an explosion hazard in the manner of a pressure vessel, but only an implosion hazard. It is possible that the vacuum vessel can become pressurized during backfilling to atmospheric pressure with nitrogen. To prevent pressurization, the vacuum vessel design incorporates a safety flange that is held in place only by vacuum pressure and is sealed by an o-ring. The flange is partially restrained to prevent rapid ejection in the case of a sudden pressurization of the vacuum vessel due to rupture of the cold mass. The vacuum vessel will also have a pressure relief valve and a burst disk installed to provide further protection from overpressure.

A safety note was has been written to document the design and operation of the Spectrometer Solenoid and is included with this document (LBNL Engineering Note 10280). The note includes details of the strength analyses for the magnet cold mass (helium vessel) and vacuum vessel.

Task 4: Operation of magnet power supplies

The Spectrometer Solenoid magnet will be energized by a series of five rack mounted power supplies. Three of the supplies are rated at 300 amps and the other two at 60 amps. During charging of the magnets, the voltage at the lead connection to the magnet is limited to 10 volts or less. At steady state operating current, the lead voltage is in the 1 to 2 volt range. During a magnet quench, the lead voltage can rise to the 10 to 20 volt range. Overall, the magnet leads do not pose an electrical hazard.

The Spectrometer Solenoid power supply racks are fed by 208V electrical power. The 208 volts can be a hazard to personnel if it is accessible while energized. The power supply racks have been upgraded to the appropriate LBNL safety standards, including physical barriers to prevent access to energized circuits.

Task 5: Testing of magnets with current in superconducting coils

During testing of the Spectrometer Solenoid magnet, the internal coils will be charged to a current of up to 275 amps, producing fields in the magnet bore of as much as 4 Tesla. The high magnetic fields present several potential hazards: extremely high forces can be exerted on magnetic materials, persons with a pacemaker can be at risk of malfunction, and credit cards and electronic devices can be affected. The calculated field map in the region of the magnet at full current is shown in Figure 3.

To protect those individuals with pacemakers, the 5 gauss line will be clearly marked off with caution tape. No one with a pacemaker should be inside the 5 gauss line when the magnet is energized. Also, to prevent the possibility of loose magnetic materials from becoming airborne hazards during testing, a pre-test search of the area within the 5 gauss line will be conducted so that all loose magnetic materials are removed (such as hand tools, electronic boxes, hardware, etc.). Individuals will be responsible for not bringing other items such as credit cards, cell phones, laptops, etc. into this area during testing of the magnet.

Other Considerations

There are numerous additional tasks that are necessary to assemble and test the MICE Spectrometer Solenoid magnets that are not covered by this document. Many of these tasks may pose hazards to personnel and are not to be performed by LBNL employees. Wang NMR is a private company that has personnel and subcontractors who are trained and authorized to perform these additional tasks. Examples of tasks that are to be performed by Wang NMR personnel only are as follows:

- operation of a forklift
- operation of overhead portable cranes
- welding operations
- use of machine shop equipment
- heavy lifting
- modification of electrical utilities

Note that LBNL personnel may also perform routine, non-hazardous work that is not included in this document. However, each LBNL employee's JHA must be appropriately updated to cover any of the work performed at Wang NMR that is different from their current duties at LBNL.

At no time during the testing of the Spectrometer Solenoids will LBNL personnel be working alone. Some overnight and weekend shifts will be required during the testing, but at least two people must be present at all times. One person will be designated as the work lead and will make all operational decisions. Shifts will generally be 8 hours in duration, extending to up to 12 hours in some cases. It is anticipated that the shift work during magnet cooldown and testing will be covered by personnel from Wang NMR, LBNL, and the MICE collaboration (Fermilab, Daresbury Lab, Rutherford Appleton Lab).

Figure 1: One of two rolling stairways to be used for accessing the magnet fill port.

Building and Room Wang Livermore, CA

Enter room data (fill in blue boxes)

Building	Wang
Room	Livermore, CA
Fume hood present in room?	no
Room Height (ft)	24
Room Width (ft)	100
Room Length (ft)	130
Total volume of cryogens stored (L) (including cryomagnets, traps, LN2 freezers, etc.)	3000
Largest storage Dewar (L) (including cryomagnets, traps, LN2 freezers, etc.)	500
Largest transfer Dewar (L)	0
Largest volume of cryogen used routinely (L) (open Dewars, cryostreams, cryostats)	0
Number of 13 cu ft freezers with LN2 backup	0
Number of 25 cu ft freezers with LN2 backup	0
LN2 in cryomagnet (L)	0
LHe in cryomagnet (L)	190
Energy of cryomagnet (kJ) (enter 0 if unknown)	0

Hazard scenarios, one air exchange per hour

Routine operations (probability of one)

	% O2	Hazard Determination
Storage of cryogens	20.99%	No Hazard
Routine work	21.00%	No Hazard
Filling transfer Dewar	21.00%	No Hazard
Refilling cryomagnet	20.97%	No Hazard
Cool-down of cryomagnet	19.68%	No Hazard

Nonroutine conditions (spills, accidents, power loss, etc.)

	% O2	Hazard Determination
8 hr power outage (no air exchange)	20.91%	No Hazard
Transfer Dewar spill	21.00%	No Hazard
Complete failure of storage Dewar	20.12%	No Hazard
Magnet quench	20.66%	No Hazard

Oxygen deficiency hazard classification

Hazard class	0

Figure 2: Output screen from the ODH calculator spreadsheet.

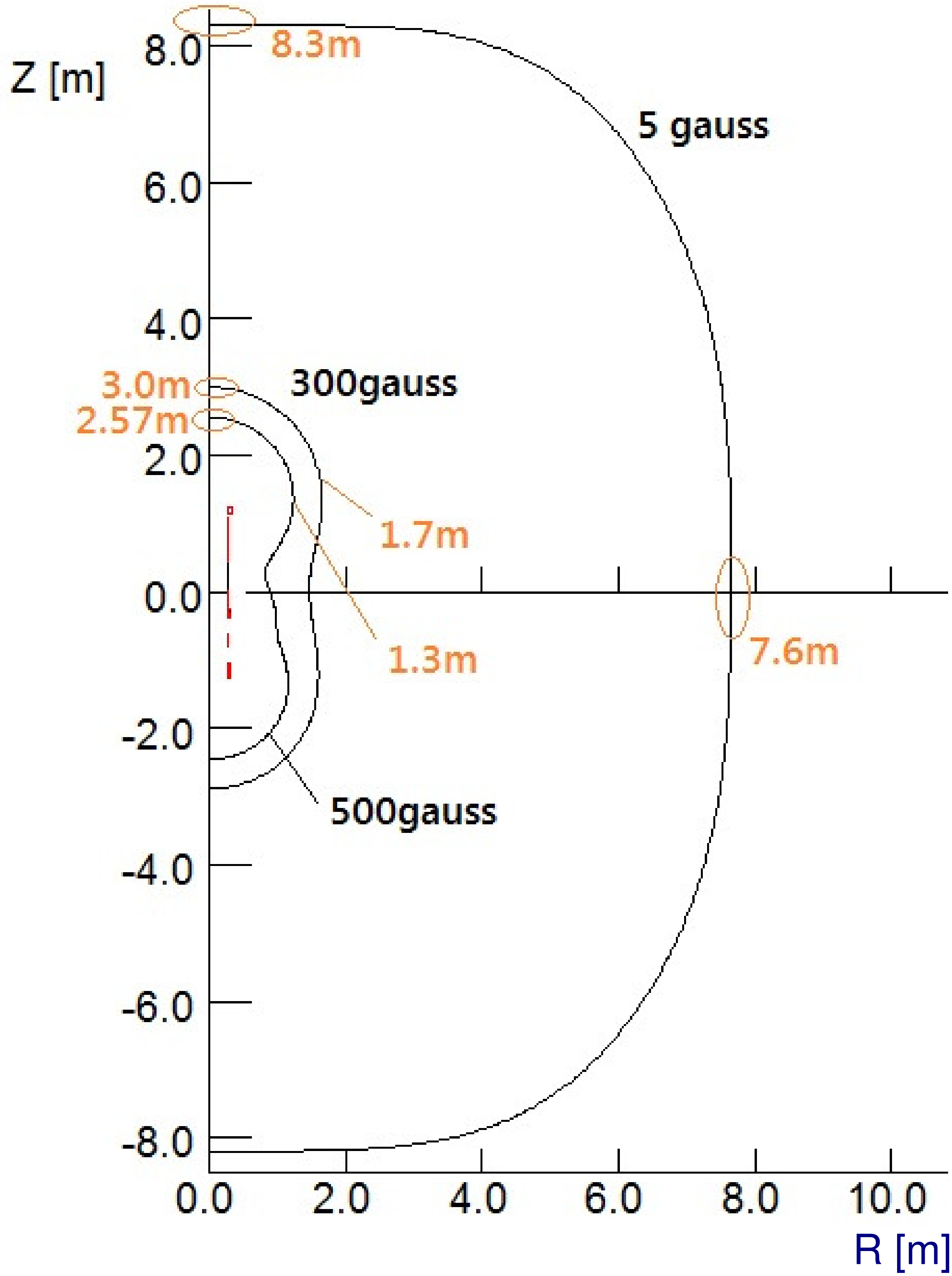

Figure 3: Field map in the vicinity of the magnet at full current.